DFS Test Report: EDCS - 506262

For

AIR-RM21A-A-K9 and AIR-RM22A-A-K9 802.11a Radio Modules (FCC ID: LDK102053)

Against the following Specifications :

FCC CFR 47 Part 15.407

Cisco Systems

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ACCREDITED

Certificate Number : 1178-01

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Title:

Dynamic Frequency Selection (DFS) Test Results

15.407: U-NII devices operating in the 5.25-5.35 GHz band and the 5.47-5.725 GHz band shall employ a TPC mechanism. The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm. A TPC mechanism is not required for systems with an e.i.r.p. of less than 500 mW.

U-NII devices operating in the 5.25-5.35 GHz and 5.47-5.725 GHz bands shall employ a DFS radar detection mechanism to detect the presence of radar systems and to avoid co-channel operation with radar systems.

1.0 UNII Device Description

1. The AIR-RM21A-A-K9 and AIR-RM22A-A-K9 operate in the following bands:
    a. 5150-5250 MHz
    b. 5250-5350 MHz
    c. 5470-5725 MHz
    d. 5725-5850 MHz

2. The maximum EIRP of the equipment is 26.5 dBm, and the minimum possible EIRP is -1 dBm.

   The AIR-RM21A-A-K9 uses integral 50 ohm, 9.5dBi Patch and 5dBi Omni-directional antennas. Below are the available 50 ohm antenna assemblies for the AIR-RM22A-A-K9 and their corresponding gains. 0dBi gain was used to set the -63 dBm threshold level (-64dBm +1 dB) during calibration of the test setup.

   AIR-ANT5135D-R (5 GHz, 3.5 dBi Omnidirectional)
   AIR-ANT5145V-R (5 GHz, 4.5 dBi Diversity Omnidirectional)
   AIR-ANT5160V-R (5 GHz, 6.0dBi Diversity Omnidirectional)
   AIR-ANT5170P-R (5 GHz, 7.0 dBi Diversity Patch)
   AIR-ANT5195P-R (5 GHz, 9.5 dBi Patch)

   Antenna gain measurement plots are included with this filing.

3. System testing was performed with the designated MPEG test file that streams full motion video at 30 frames per second from the Master to the Client IP based system.

4. This device does not exceed 27dBm eirp, so no transmit power control is implemented.

5. The Master requires 1.333 minutes to complete its power-on cycle.

6. Information regarding the parameters of the detected Radar Waveforms is not available to the end user.

7. For the 5250-5350 MHz and 5470-5725 MHz bands, the Master device provides, on aggregate, uniform loading of the spectrum across all devices by selecting an operating channel among the available channels using a random algorithm.

2.0 DFS Detection Thresholds

1. **Interference Threshold values, Master or Client incorporating In-Service Monitoring**

Maximum Transmit Power	**Value (see note)**
≥ 200 milliwatt	-64 dBm
< 200 milliwatt	-62 dBm
Note 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna Note 2: Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response.	

2. **DFS Response requirement values**

Parameter	**Value**
Non-occupancy period	Minimum 30 minutes
Channel Availability Check Time	60 seconds
Channel Move Time	10 seconds See Note 1.
Channel Closing Transmission Time	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Notes 1 and 2.
U-NII Detection Bandwidth	Minimum 80% of the 99% power bandwidth See Note 3.

Note 1: The instant that the *Channel Move Time* and the *Channel Closing Transmission Time* begins is as follows:

- For the Short pulse radar Test Signals this instant is the end of the *Burst*.
- For the Frequency Hopping radar Test Signal, this instant is the end of the last radar *Burst* generated.
- For the Long Pulse radar Test Signal this instant is the end of the 12 second period defining the radar transmission.

Note 2: The *Channel Closing Transmission Time* is comprised of 200 milliseconds starting at the beginning of the *Channel Move Time* plus any additional intermittent control signals required to facilitate *Channel* changes (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.

Note 3: During the *U-NII Detection Bandwidth* detection test, radar type 1 is used and for each frequency step the minimum percentage of detection is 90%. Measurements are performed with no data traffic.

3.0 Radar Test Waveforms

This section provides the parameters for required test waveforms, minimum percentage of successful detections, and the minimum number of trials that must be used for determining DFS conformance. Step intervals of 0.1 microsecond for Pulse Width, 1 microsecond for PRI, 1 MHz for chirp width and 1 for the number of pulses will be utilized for the random determination of specific test waveforms.

1. Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (µsec)	PRI (µsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Trials
1	1	1428	18	60%	30
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120

A minimum of 30 unique waveforms are required for each of the short pulse radar types 2 through 4. For short pulse radar type 1, the same waveform is used a minimum of 30 times. If more than 30 waveforms are used for short pulse radar types 2 through 4, then each additional waveform must also be unique and not repeated from the previous waveforms. The aggregate is the average of the percentage of successful detections of short pulse radar types 1-4.

2. Long Pulse Radar Test Waveform

Radar Type	Pulse Width (µsec)	Chirp Width (MHz)	PRI (µsec)	Number of Pulses per *Burst*	Number of *Bursts*	Minimum Percentage of Successful Detection	Minimum Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

The parameters for this waveform are randomly chosen. Thirty unique waveforms are required for the Long Pulse radar test signal. If more than 30 waveforms are used for the Long Pulse radar test signal, then each additional waveform must also be unique and not repeated from the previous waveforms.

Each waveform is defined as follows:

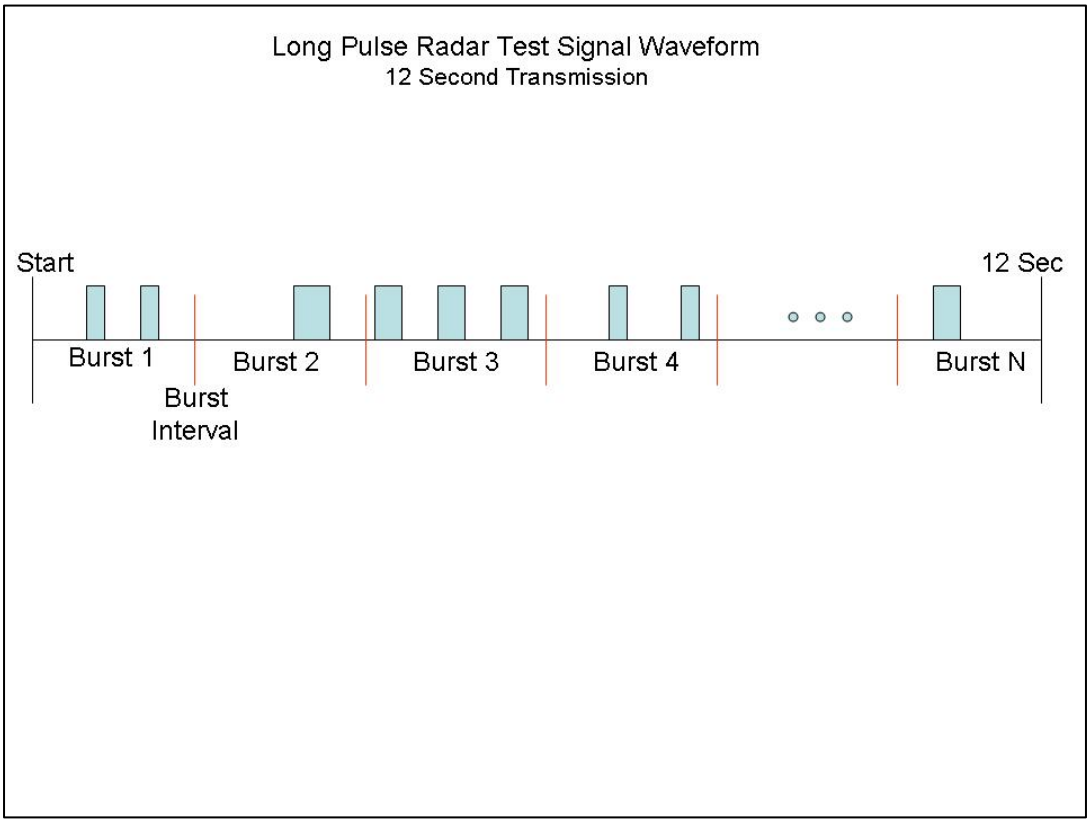
1) The transmission period for the Long Pulse Radar test signal is 12 seconds.
2) There are a total of 8 to 20 Bursts in the 12 second period, with the number of Bursts being randomly chosen. This number is Burst_Count.
3) Each Burst consists of 1 to 3 pulses, with the number of pulses being randomly chosen. Each Burst within the 12 second sequence may have a different number of pulses.

4) The pulse width is between 50 and 100 microseconds, with the pulse width being randomly chosen. Each pulse within a Burst will have the same pulse width. Pulses in different Bursts may have different pulse widths.
5) Each pulse has a linear FM chirp between 5 and 20 MHz, with the chirp width being randomly chosen. Each pulse within a Burst will have the same chirp width. Pulses in different Bursts may have different chirp widths. The chirp is centered on the pulse. For example, with a radar frequency of 5300 MHz and a 20 MHz chirped signal, the chirp starts at 5290 MHz and ends at 5310 MHz.
6) If more than one pulse is present in a Burst, the time between the pulses will be between 1000 and 2000 microseconds, with the time being randomly chosen. If three pulses are present in a Burst, the time between the first and second pulses is chosen independently of the time between the second and third pulses.
7) The 12 second transmission period is divided into even intervals. The number of intervals is equal to Burst_Count. Each interval is of length (12,000,000 / Burst_Count) microseconds. Each interval contains one Burst. The start time for the Burst, relative to the beginning of the interval, is between 1 and [(12,000,000 / Burst_Count) – (Total Burst Length) + (One Random PRI Interval)] microseconds, with the start time being randomly chosen. The step interval for the start time is 1 microsecond. The start time for each Burst is chosen independently.

A representative example of a Long Pulse radar test waveform:

1) The total test signal length is 12 seconds.
2) 8 Bursts are randomly generated for the Burst_Count.
3) Burst 1 has 2 randomly generated pulses.
4) The pulse width (for both pulses) is randomly selected to be 75 microseconds.
5) The PRI is randomly selected to be at 1213 microseconds.
6) Bursts 2 through 8 are generated using steps 3 – 5.
7) Each Burst is contained in even intervals of 1,500,000 microseconds. The starting location for Pulse 1, Burst 1 is randomly generated (1 to 1,500,000 minus the total Burst 1 length + 1 random PRI interval) at the 325,001 microsecond step. Bursts 2 through 8 randomly fall in successive 1,500,000 microsecond intervals (i.e. Burst 2 falls in the 1,500,001 – 3,000,000 microsecond range).

Graphical Representation of a Long Pulse radar Test Waveform



3. **Frequency Hopping Radar Test Waveform**

Radar Type	Pulse Width (µsec)	PRI (µsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Trials
6	1	333	9	.333	300	70%	30

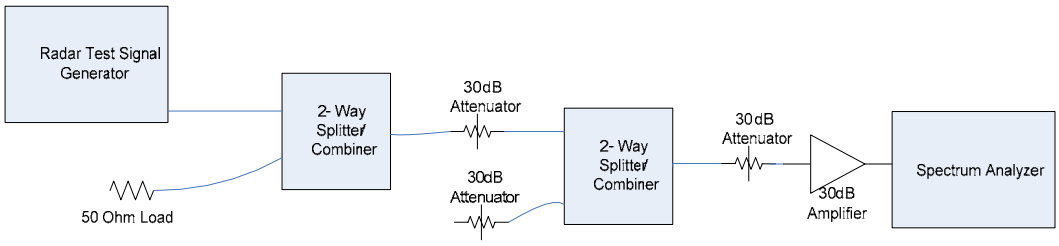
For the Frequency Hopping Radar Type, the same *Burst* parameters are used for each waveform. The hopping sequence is different for each waveform and a 100-length segment is selected[1] from the hopping sequence defined by the following algorithm:

The first frequency in a hopping sequence is selected randomly from the group of 475 integer frequencies from 5250 – 5724 MHz. Next, the frequency that was just chosen is removed from the group and a frequency is randomly selected from the remaining 474 frequencies in the group. This process continues until all 475 frequencies are chosen for the set. For selection of a random frequency, the frequencies remaining within the group are always treated as equally likely.

4.0 Radar Waveform Calibration

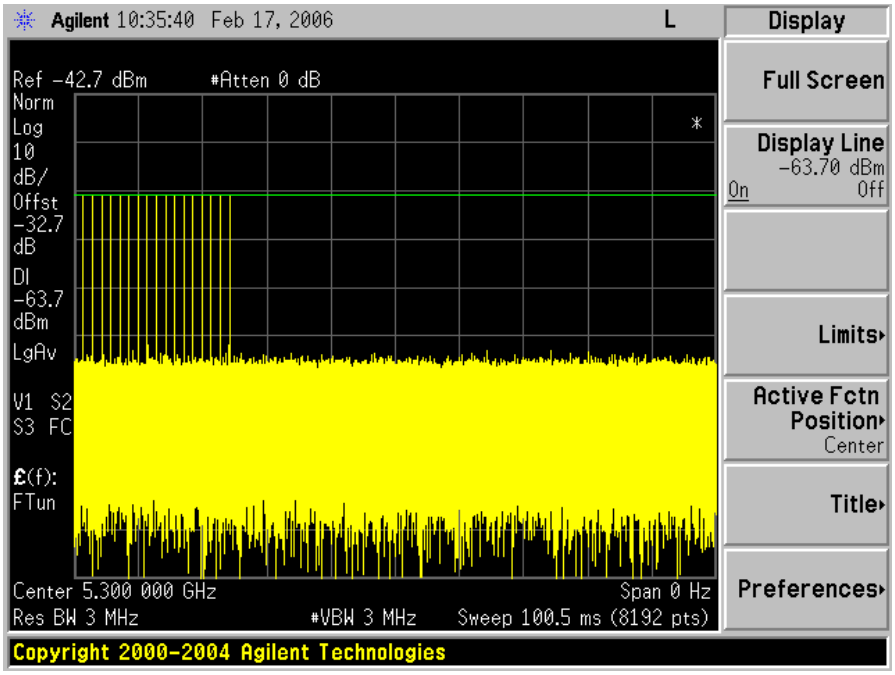
1. The following equipment setup was used to calibrate the conducted Radar Waveform. A spectrum analyzer was used to establish the test signal level for each radar type. During this process there were no transmissions by either the Master or Client Device. The spectrum analyzer was switched to the zero span (Time Domain) mode at the frequency of the Radar Waveform generator. Peak detection was utilized. The spectrum analyzer resolution bandwidth (RBW) and video bandwidth (VBW) were set to 3 MHz.

   The signal generator amplitude was set so that the power level measured at the spectrum analyzer was -63dBm. The 30dB amplifier gain was entered as an amplitude offset on the spectrum analyzer.

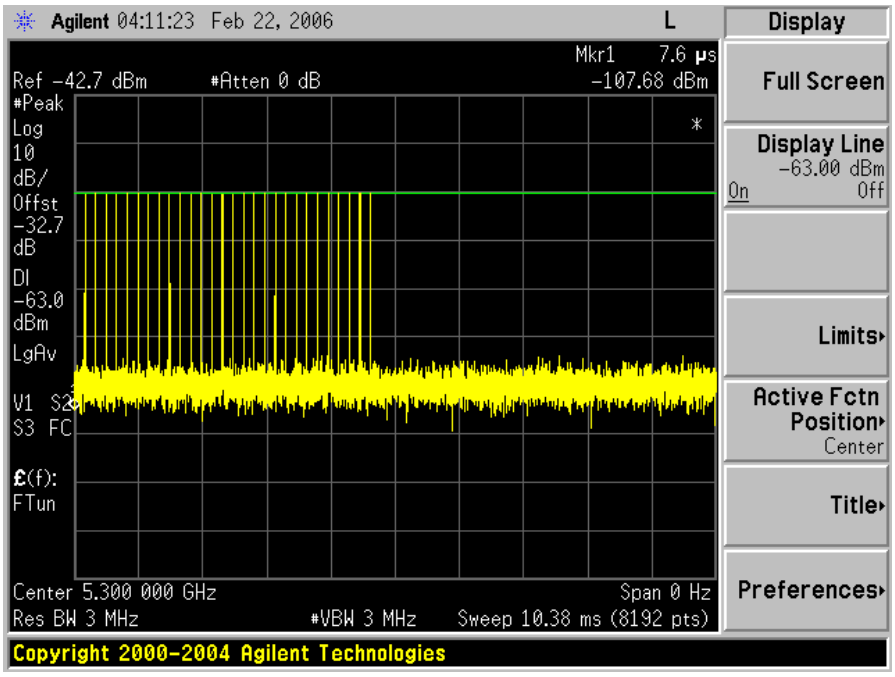


Conducted Calibration Setup

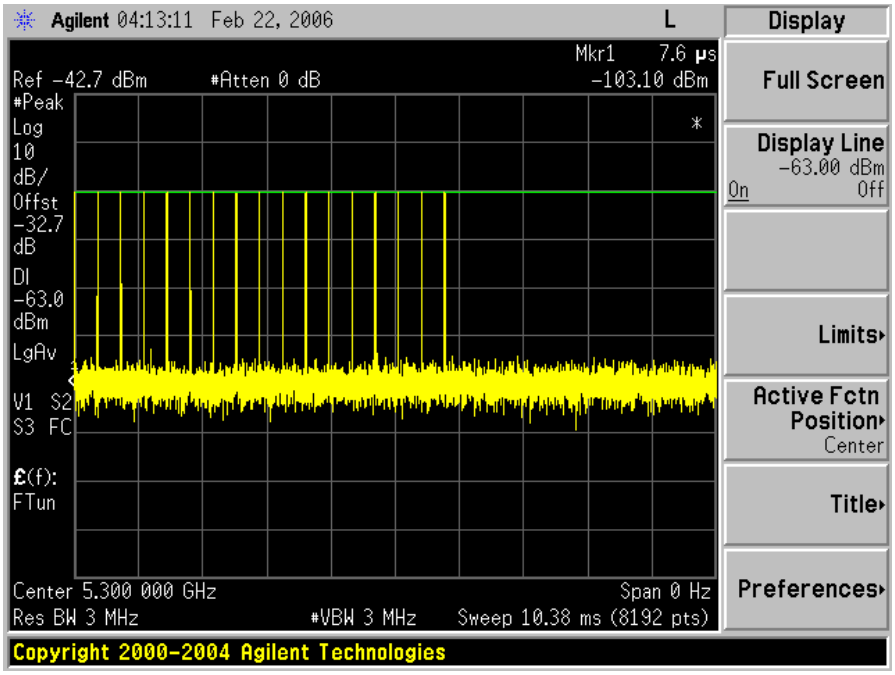
2. Following are the calibration plots for each of the required radar waveforms.



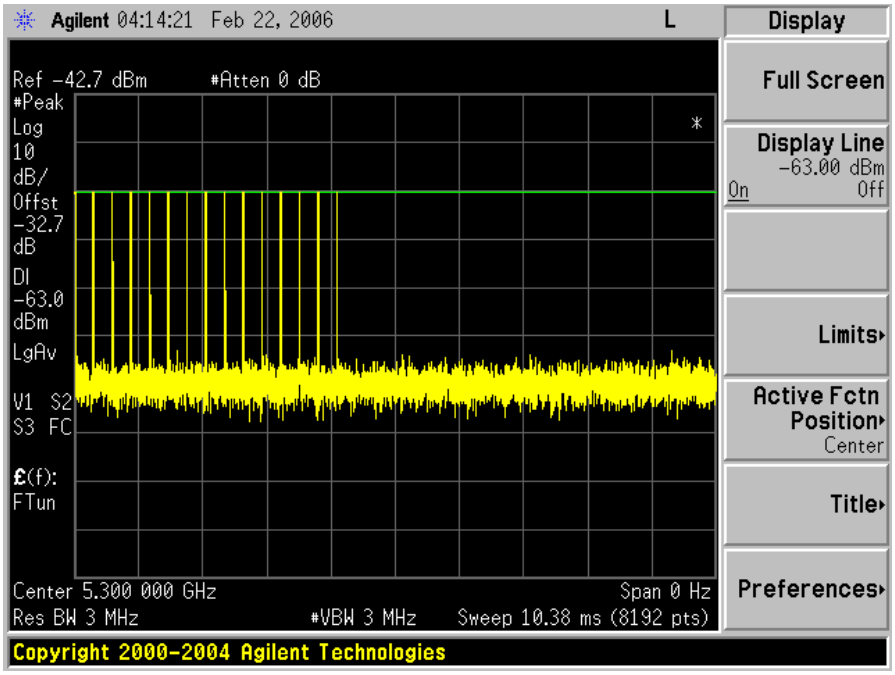
Bin 1 Radar Calibration



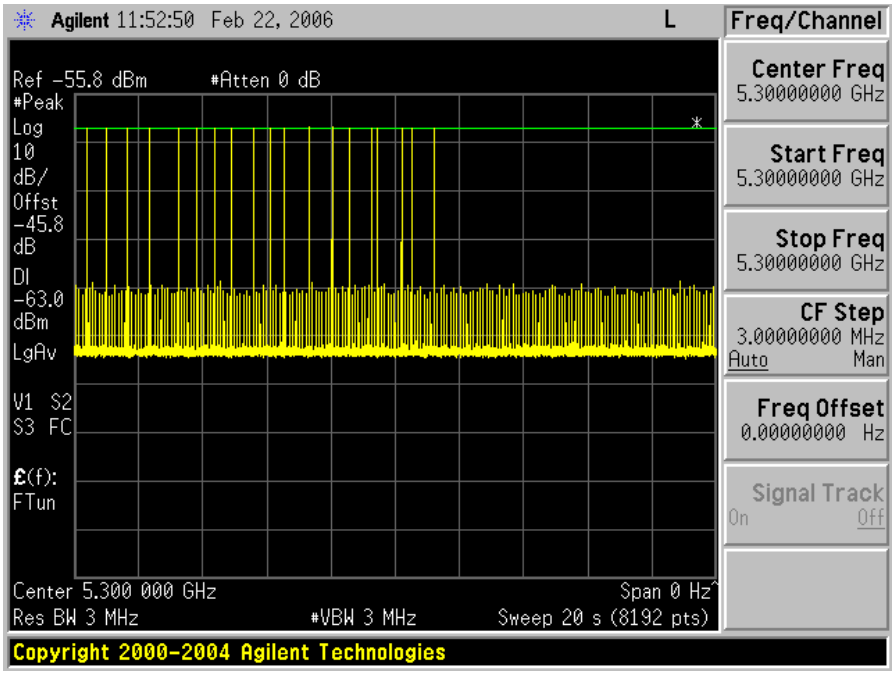
Bin 2 Radar Calibration



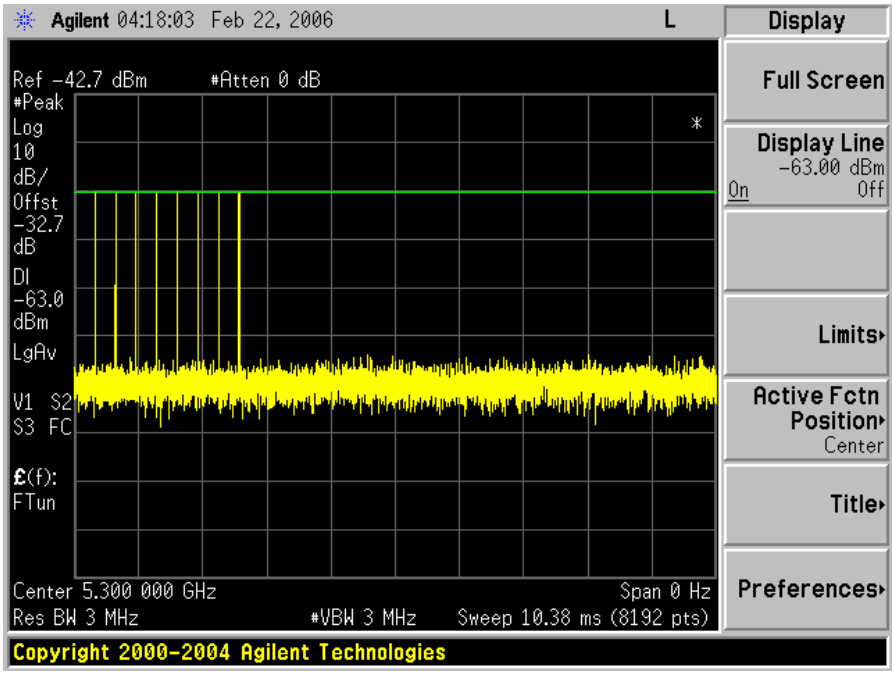
Bin 3 Radar Calibration



Bin 4 Radar Calibration



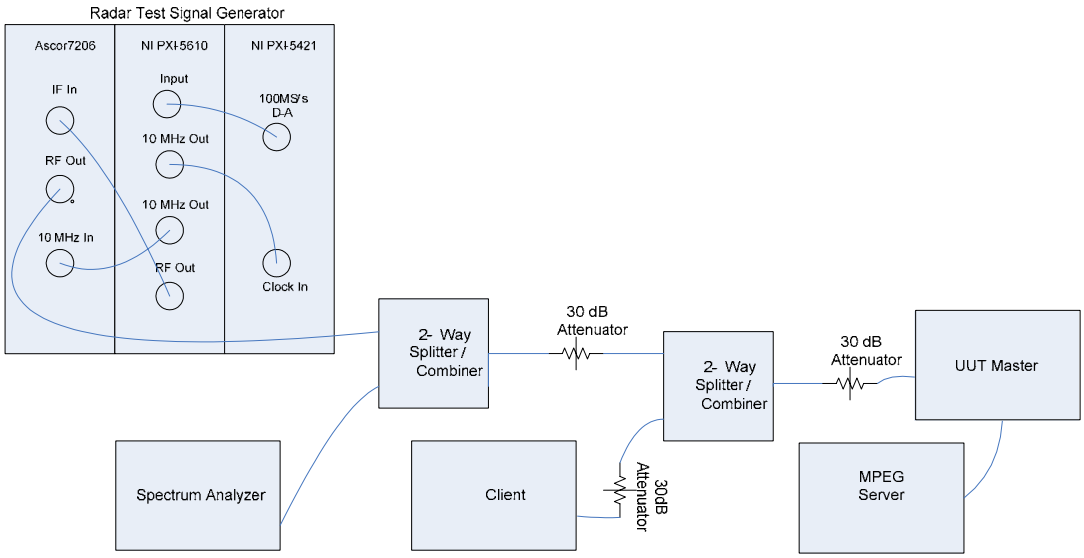
Bin 5 Radar Calibration



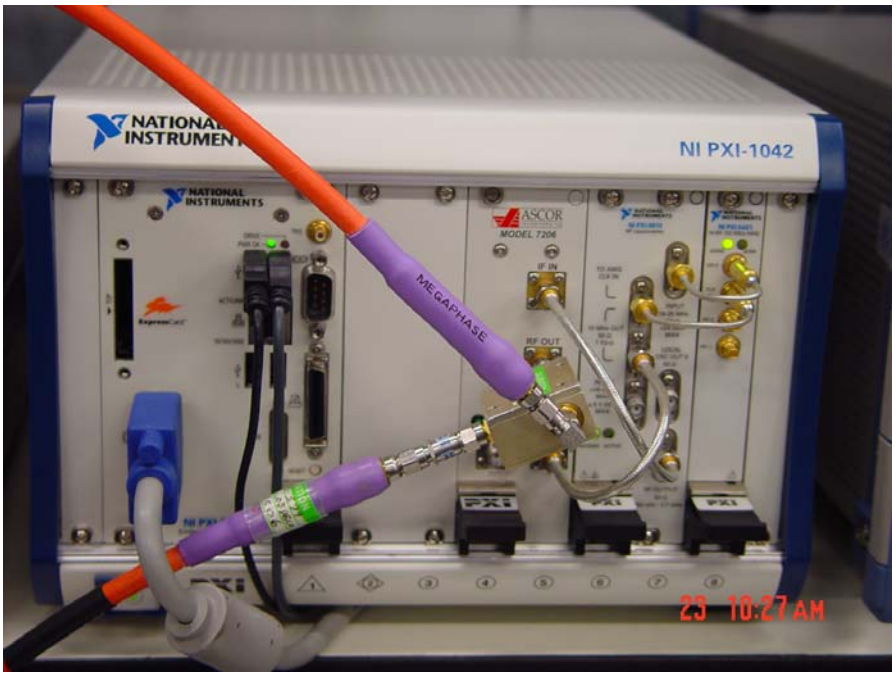
Bin 6 Radar Calibration

5.0 Test Procedure/Results

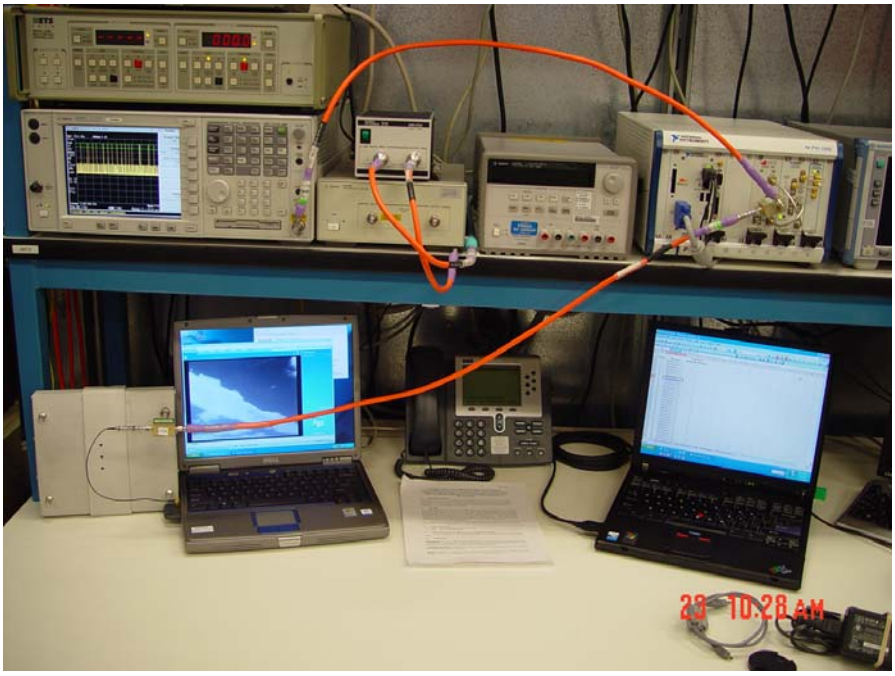
1. A spectrum analyzer is used as a monitor to verify that the UUT has vacated the Channel within the (Channel Closing Transmission Time and Channel Move Time, and does not transmit on a Channel during the Non-Occupancy Period after the detection and Channel move. It is also used to monitor UUT transmissions during the Channel Availability Check Time.
2. Following is the test setup used to generate the Radar Waveforms, and for all DFS tests described herein.



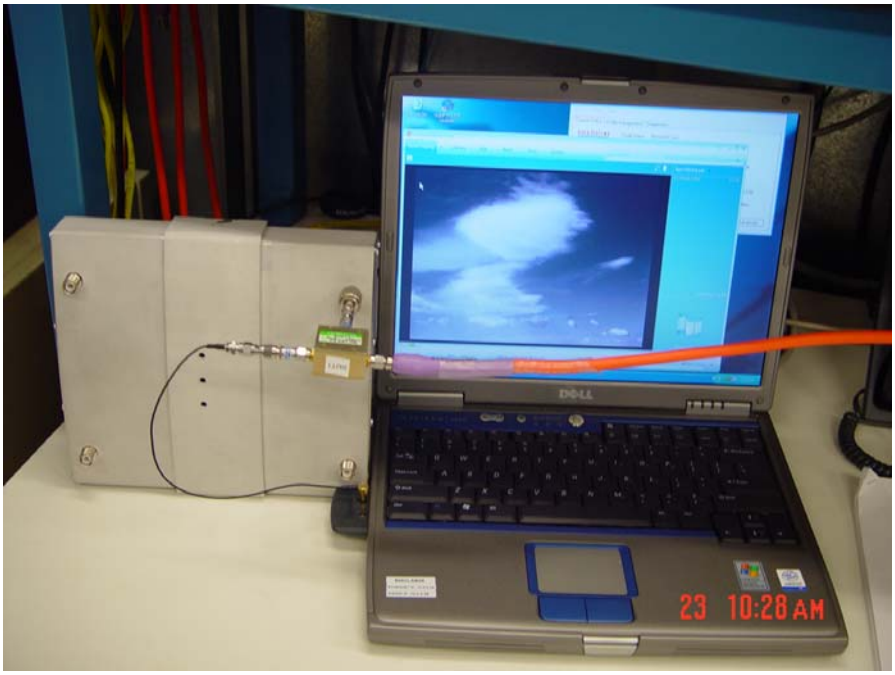
Conducted Setup: Radar Test Waveforms are injected into the Master



Radar Test Signal Generator



DFS Test Setup (Does not reflect actual unit under test)



DFS Setup: UUT and Client (Does not reflect actual unit under test)

The test setup is constructed of the following equipment:

Radar Test Signal Generator
- National Instruments NI PXI-1042 8-Slot 3U Chassis
- National Instruments NI PXI-5421 16-Bit 100MS/s Arbitrary Waveform Generator
- National Instruments NI PXI-5610 2.7GHz RF Upconverter
- Ascor 7206 PXI 4.9 to 6GHz Upconverter

Agilent E4448A Spectrum Analyzer
Mini-Circuits ZFSC-2-9G Splitter/Combiner (Qty. 2)
Mini-Circuits BW-S30W2 30dB Attenuator (Qty. 3)
Agilent 8449B Preamplifier (used for detection level calibration only)
Megaphase SF26 S1S1 36" Coaxial Cable (Qty. 2)
Dell 600M Laptop (Qty. 2: 1 for wireless client, 1 for MPEG server)
Cisco AIR-CB21AG 802.11a/b/g NIC card (wireless client)

The waveform parameters from within the bounds of the signal type are selected randomly using uniform distribution.

3. **UNII Detection Bandwidth**: All UNII channels for this device have identical Channel bandwidths. Therefore, all DFS testing was done at 5300 MHz. The 99% channel bandwidth is 16.4MHz. (See the 26dB BW section of the RF report for further measurement details).

   The generating equipment is configured as shown in the Conducted Test Setup above. A single *Burst* of the short pulse radar type 1 is produced at 5300MHz at a -63dBm level. The UUT is set up as a standalone device (no associated Client and no traffic).

   A single radar Burst is generated for a minimum of 10 trials, and the response of the UUT is noted. The UUT must detect the Radar Waveform 90% or more of the time.

   The radar frequency is increased in 1 MHz steps, repeating the above test sequence, until the detection rate falls below 90%. The highest frequency at which detection is greater than or equal to 90% is denoted as Fh.

   The radar frequency is decreased in 1 MHz steps, repeating the above test sequence, until the detection rate falls below 90%. The lowest frequency at which detection is greater than or equal to 90% is denoted as Fl.

   The U-NII Detection Bandwidth is calculated as follows:

   U-NII Detection Bandwidth = $F_H - F_L$

   The U-NII Detection Bandwidth must be at least 80% of the UUT transmitter 99% power, otherwise, the UUT does not comply with DFS requirements.

UNII Detection Bandwidth Results

EUT Frequency=5300MHz											
	DFS Detection Trials (1=Detection, Blank= No Detection)										
Radar Frequency (MHz)	1	2	3	4	5	6	7	8	9	10	Detection Rate (%)
5292											0%
5293 (Fl)	1	1	1	1	1	1	1	1	1	1	100%
5294	1	1	1	1	1	1	1	1	1	1	100%
5295	1	1	1	1	1	1	1	1	1	1	100%
5296	1	1	1	1	1	1	1	1	1	1	100%
5297	1	1	1	1	1	1	1	1	1	1	100%
5298	1	1	1	1	1	1	1	1	1	1	100%
5299	1	1	1	1	1	1	1	1	1	1	100%
5300	1	1	1	1	1	1	1	1	1	1	100%
5301	1	1	1	1	1	1	1	1	1	1	100%
5302	1	1	1	1	1	1	1	1	1	1	100%
5303	1	1	1	1	1	1	1	1	1	1	100%
5304	1	1	1	1	1	1	1	1	1	1	100%
5305	1	1	1	1	1	1	1	1	1	1	100%
5306	1	1	1	1	1	1	1	1	1	1	100%
5307 (Fh)	1	1	1	1	1	1	1	1	1	1	100%
5308											0%
Detection Bandwidth = Fh-Fl = 5307MHz-5293MHz = 14MHz											
EUT 99% Bandwidth = 16.4MHz											
16.4MHz*80% = 13.12MHz											

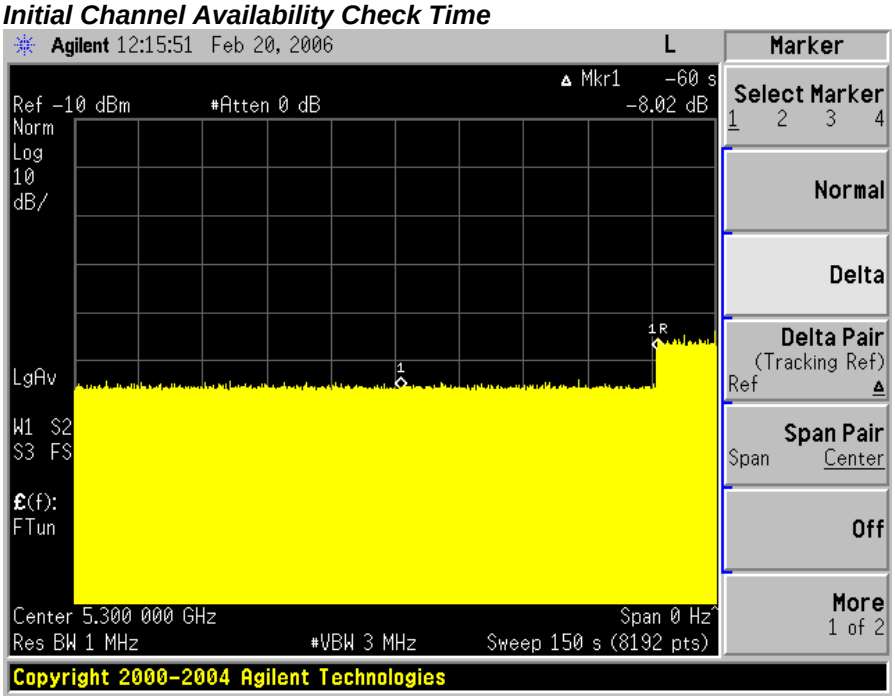
4. The **Initial Channel Availability Check Time** tests that the UUT does not emit beacon, control, or data signals on the test Channel until the power-up sequence has been completed and the U-NII device checks for Radar Waveforms for one minute on the test Channel. This test does not use any Radar Waveforms.

   The U-NII device is powered on and be instructed to operate at 5300 MHz. At the same time the UUT is powered on, the spectrum analyzer is set to zero span mode with a 1 MHz resolution bandwidth at 5300MHz with a 2.5 minute sweep time. The analyzer's sweep will be started the same time power is applied to the U-NII device.

   The UUT should not transmit any beacon or data transmissions until at least 1 minute after the completion of the power-on cycle.

   The initial power up time of the UUT is indicated by marker 1 in the plot. Initial beacons/data transmissions are indicated by marker 1R.

Initial Channel Availability Check Time



5. **Radar Burst at the Beginning of the Channel Availability Check Time:** The steps below define the procedure to verify successful radar detection on the selected Channel during a period equal to the Channel Availability Check Time and avoidance of operation on that Channel when a radar Burst with a level equal to the DFS Detection Threshold + 1 dB (-63dBm) occurs at the beginning of the Channel Availability Check Time.

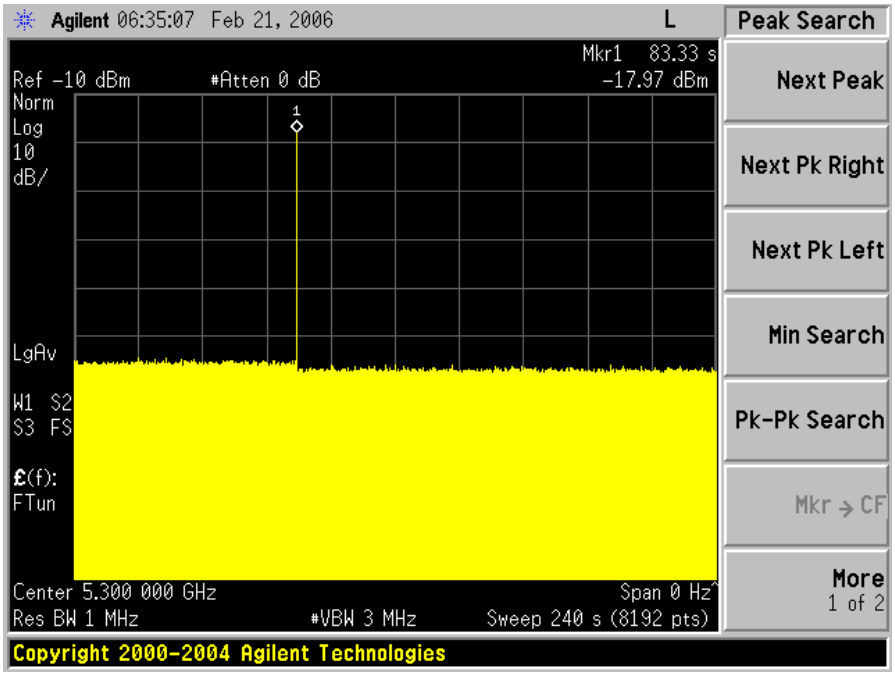
   The UUT is powered on at T_0. T_1 denotes the instant when the UUT has completed its power-up sequence. The Channel Availability Check Time commences at instant T_1 and will end no sooner than T_1 + 60 seconds.

   A single Burst of short pulse of radar type 1 at -63 dBm will commence within a 6 second window starting at T_1.

   Visual indication on the UUT of successful detection of the radar Burst will be recorded and reported. Observation of emissions at 5300MHz will continue for 2.5 minutes after the radar Burst has been generated.

   Verify that during the 2.5 minute measurement window no UUT transmissions occurred at 5300MHz.

Radar Burst at the Beginning of the Channel Availability Check Time



6. **Radar Burst at the End of the Channel Availability Check Time:** The steps below define the procedure to verify successful radar detection on the selected Channel during a period equal to the Channel Availability Check Time and avoidance of operation on that Channel when a radar Burst with a level equal to the DFS Detection Threshold + 1 dB (-63dBm) occurs at the end of the Channel Availability Check Time.

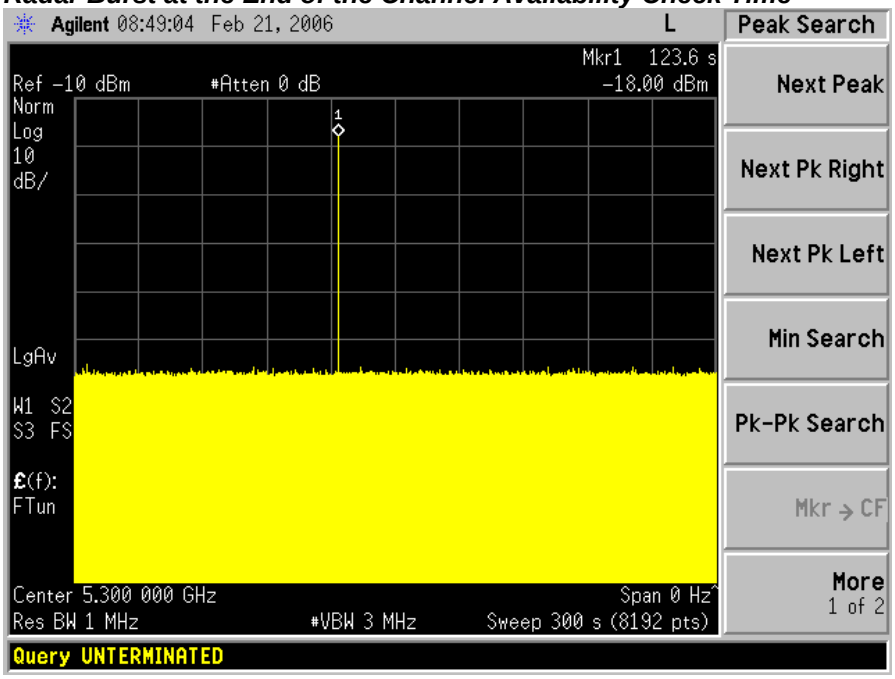
   The UUT is powered on at T_0. T_1 denotes the instant when the UUT has completed its power-up sequence. The Channel Availability Check Time commences at instant T_1 and will end no sooner than T_1 + 60 seconds.

   A single Burst of short pulse of radar type 1 at -63 dBm will commence within a 6 second window starting at T_1+ 54 seconds.

   Visual indication on the UUT of successful detection of the radar Burst will be recorded and reported. Observation of emissions at 5300MHz will continue for 2.5 minutes after the radar Burst has been generated.

   Verify that during the 2.5 minute measurement window no UUT transmissions occurred at 5300MHz.

Radar Burst at the End of the Channel Availability Check Time



6. In-Service Monitoring for Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period

These tests define how the following DFS parameters are verified during In-Service Monitoring; Channel Closing Transmission Time, Channel Move Time, and Non-Occupancy Period.

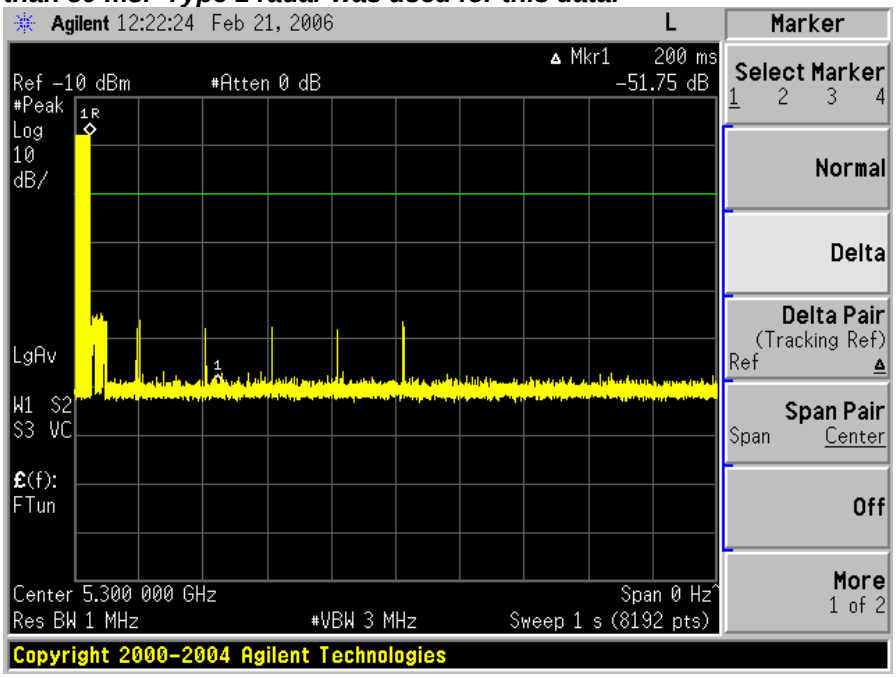
The steps below define the procedure to determine the above mentioned parameters when a radar Burst with a level equal to the DFS Detection Threshold + 1dB (-63dBm) is generated on the Operating Channel of the U-NII device.

A U-NII device operating as a Client Device will associate with the UUT (Master) at 5300 MHz. Stream the MPEG test file from the Master Device to the Client Device on the selected Channel for the entire period of the test.

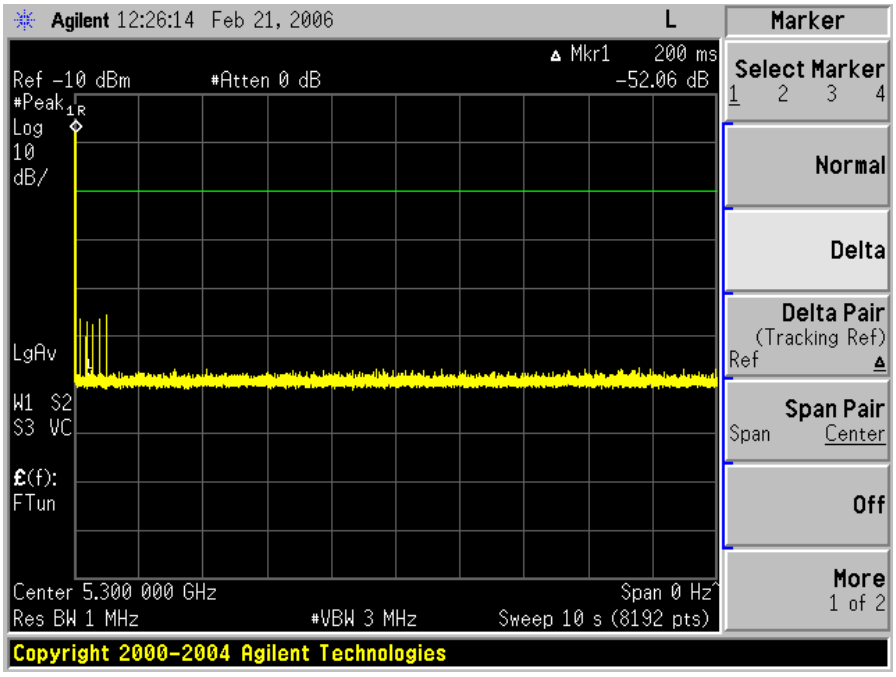
At time T_0 the Radar Waveform generator sends a Burst of pulses for each of the radar types at -63dBm.

Observe the transmissions of the UUT at the end of the radar Burst on the Operating Channel for duration greater than 10 seconds. Measure and record the transmissions from the UUT during the observation time (Channel Move Time). Compare the Channel Move Time and Channel Closing Transmission Time results to the limits defined in the *DFS Response requirement values table*.

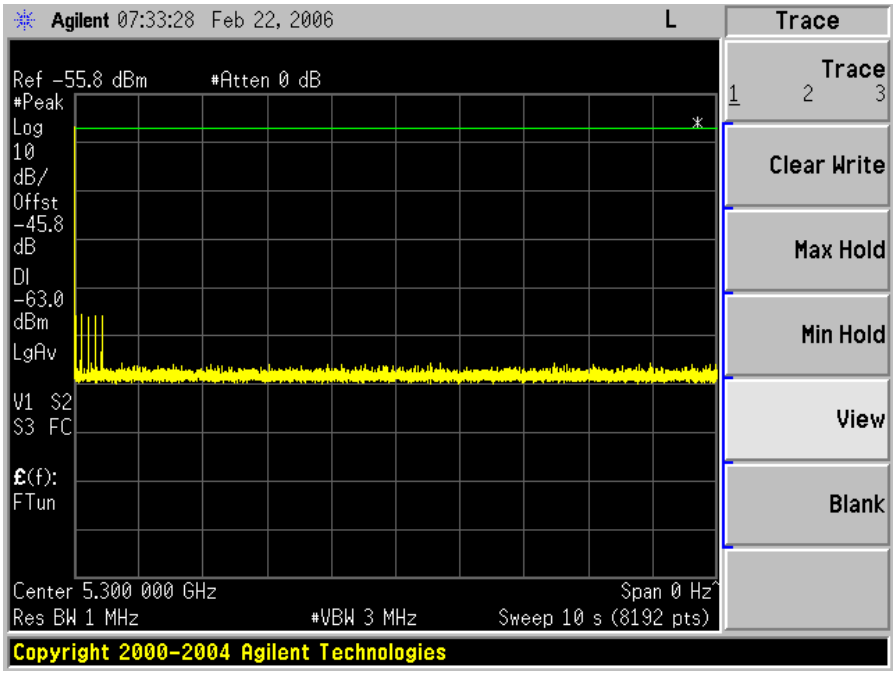
The following plot demonstrates a channel close time of 50ms, with an aggregate of no more than 50 ms. Type 1 radar was used for this data.



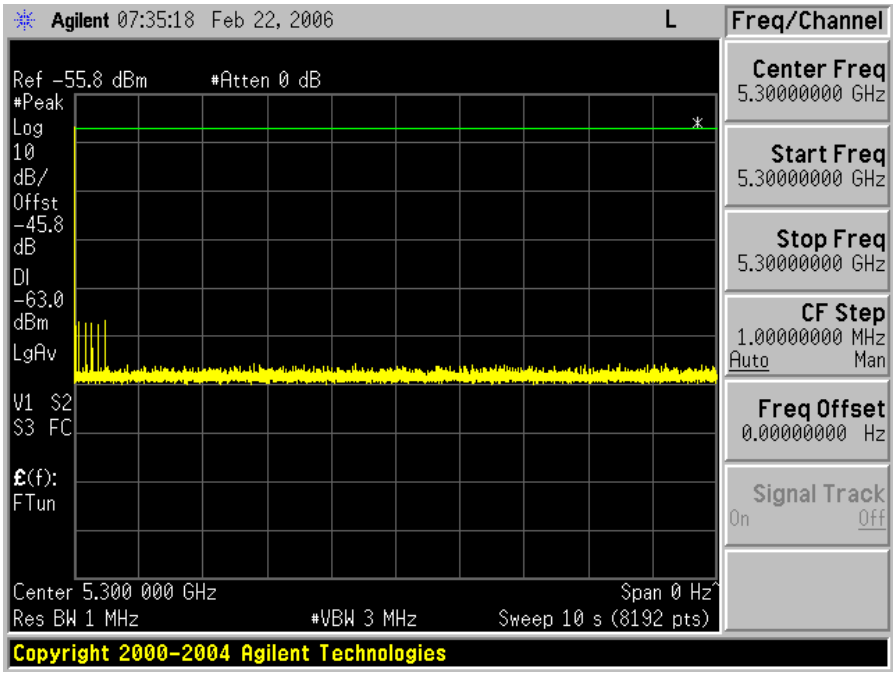
Channel Move Time, Channel Closing Transmission Time for Type 1 radar.



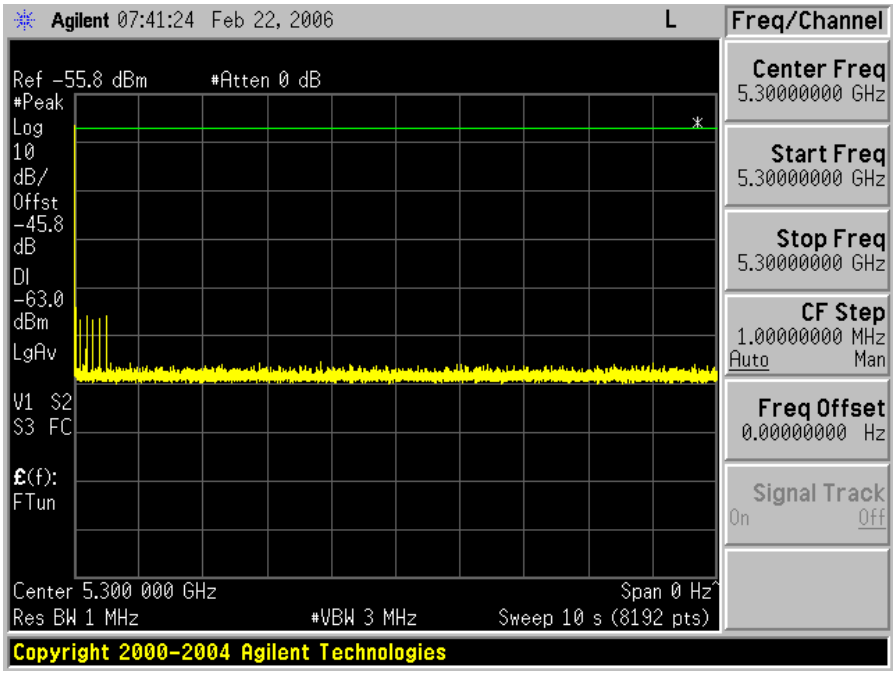
Channel Move Time, Channel Closing Transmission Time for Type 2 radar.



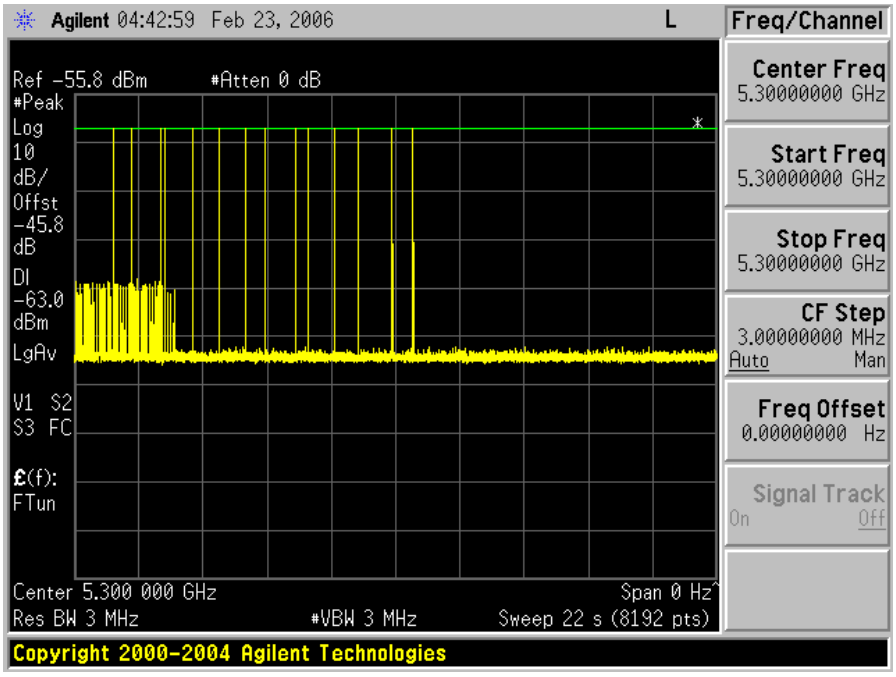
Channel Move Time, Channel Closing Transmission Time for Type 3 radar.



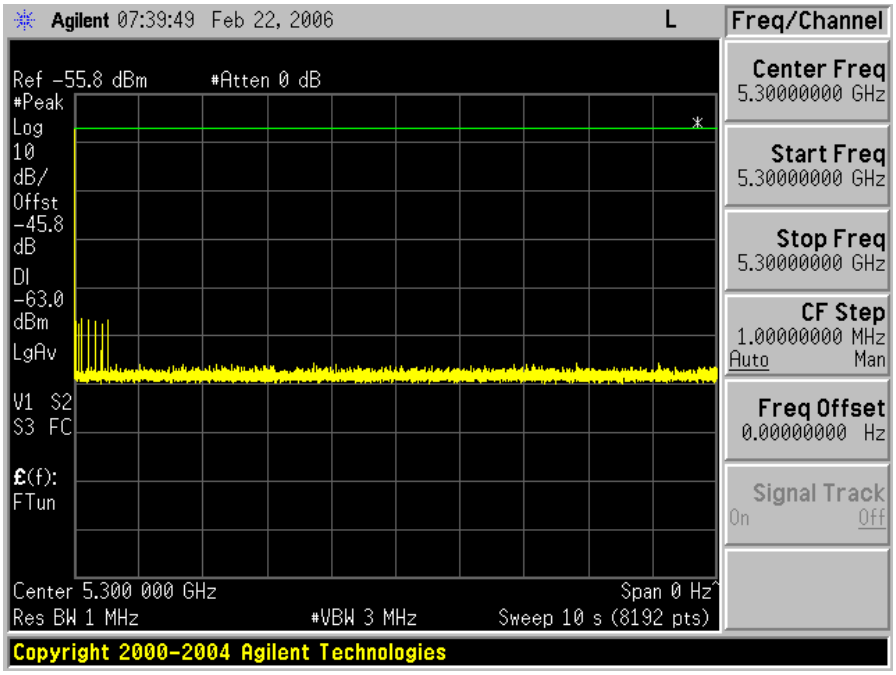
Channel Move Time, Channel Closing Transmission Time for Type 4 radar.



Channel Move Time, Channel Closing Transmission Time for Type 5 radar.

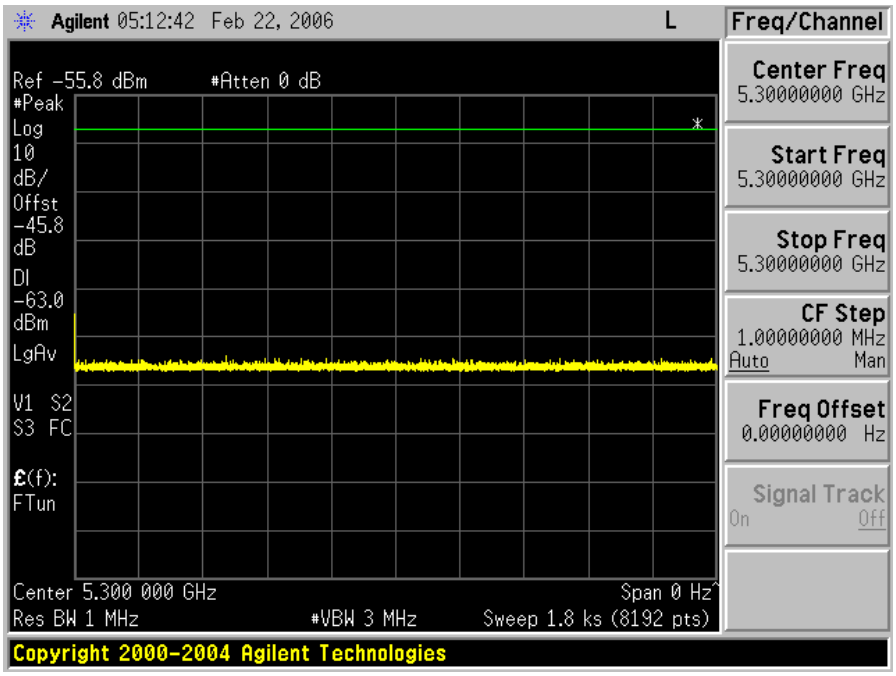


Channel Move Time, Channel Closing Transmission Time for Type 6 radar.



Measure the UUT for more than 30 minutes following the channel close/move time to verify that the UUT does not resume any transmissions on this Channel.

30 Minute Non-Occupancy Period (using Type 1 radar)



7. Statistical Performance Check

The steps below define the procedure to determine the minimum percentage of detection when a radar burst with a level equal to the DFS Detection Threshold + 1dB (-63dBm) is generated on the Operating Channel of the U-NII device.

A U-NII device operating as a Client Device will associate with the UUT (Master) at 5300 MHz. Stream the MPEG test file from the Master Device to the Client Device on the selected Channel for the entire period of the test.

The Radar Waveform generator sends the individual waveform for each of the radar types 1-6 at -63dbm. Statistical data will be gathered to determine the ability of the device to detect the radar test waveforms. The device can utilize a test mode to demonstrate when detection occurs to prevent the need to reset the device between trial runs. The percentage of successful detection is calculated by:

$$\frac{TotalWaveformDetections}{TotalWaveformTrials} \times 100$$ = Probability of Detection Radar Waveform

The Minimum number of trails, minimum percentage of successful detection and the average minimum percentage of successful detection are found in the *Radar Test Waveforms* section.

Type 1 Radar Statistical Performance

Trial #	Pulse Width (us)	PRI (us)	Pulses/Burst	1=Detection Blank=No Detection
1	1	1428	18	1
2	1	1428	18	1
3	1	1428	18	1
4	1	1428	18	
5	1	1428	18	1
6	1	1428	18	1
7	1	1428	18	1
8	1	1428	18	1
9	1	1428	18	1
10	1	1428	18	1
11	1	1428	18	1
12	1	1428	18	
13	1	1428	18	
14	1	1428	18	1
15	1	1428	18	1
16	1	1428	18	1
17	1	1428	18	
18	1	1428	18	1
19	1	1428	18	1
20	1	1428	18	1
21	1	1428	18	1
22	1	1428	18	1
23	1	1428	18	1
24	1	1428	18	1
25	1	1428	18	1
26	1	1428	18	1
27	1	1428	18	1
28	1	1428	18	1
29	1	1428	18	1
30	1	1428	18	1
			Detection Percentage	87% (>60%)

Type 2 Radar Statistical Performance

Trial #	Pulses/Burst	Pulse Width (us)	PRI (us)	1=Detection Blank=No Detection
1	25	3.3	186	1
2	25	2.2	193	1
3	29	1.8	194	1
4	29	2.4	230	1
5	23	1.1	207	1
6	27	1.9	187	1
7	27	3.3	164	1
8	23	4.5	197	1
9	26	3.9	188	1
10	26	2.0	199	1
11	28	4.2	190	1
12	29	2.9	204	1
13	26	5.0	175	1
14	28	4.0	191	1
15	27	2.0	208	1
16	28	3.9	197	1
17	25	1.7	205	1
18	29	1.0	180	1
19	23	4.4	171	1
20	27	3.6	228	
21	24	1.0	159	1
22	25	4.1	191	1
23	25	3.8	170	1
24	29	1.0	222	1
25	28	2.0	229	1
26	23	1.0	208	1
27	28	2.2	154	1
28	28	1.8	230	1
29	23	1.8	166	1
30	25	2.1	226	1
			Detection Percentage	97% (>60%)

Type 3 Radar Statistical Performance

Trial #	Pulses/Burst	Pulse Width (us)	PRI (us)	1=Detection Blank=No Detection
1	18	7.5	460	1
2	16	7.4	424	1
3	16	7.4	240	1
4	16	6.0	288	1
5	16	9.8	329	1
6	16	9.2	378	1
7	18	9.8	223	1
8	17	8.0	362	1
9	17	6.1	373	
10	16	8.7	461	
11	16	6.9	376	1
12	17	8.9	308	1
13	18	9.9	471	1
14	17	9.3	355	1
15	18	6.1	446	1
16	16	6.9	478	1
17	18	7.6	482	1
18	16	6.8	403	1
19	17	6.5	405	1
20	16	6.5	285	1
21	17	7.4	316	1
22	16	7.0	427	1
23	18	6.0	266	1
24	16	6.5	230	1
25	17	8.2	489	1
26	16	6.3	267	1
27	16	8.0	370	1
28	16	9.0	354	1
29	18	6.6	284	1
30	16	6.0	390	1
			Detection Percentage	93% (>60%)

Type 4 Radar Statistical Performance

Trial #	Pulses/Burst	Pulse Width (us)	PRI (us)	1=Detection Blank=No Detection
1	12	11.2	248	1
2	12	13.6	204	1
3	15	15.1	238	
4	13	14.8	429	1
5	15	18.6	460	1
6	14	19.0	247	1
7	12	15.0	211	1
8	13	12.0	247	1
9	16	16.7	378	1
10	14	19.4	417	1
11	13	15.0	418	1
12	13	18.8	283	1
13	12	13.0	226	1
14	12	14.9	259	1
15	16	16.1	207	
16	14	16.9	235	1
17	12	17.1	491	
18	15	17.8	267	1
19	13	12.5	355	1
20	14	11.7	425	1
21	15	12.7	284	1
22	16	15.2	318	1
23	13	19.6	346	1
24	13	13.8	356	1
25	13	17.0	359	1
26	14	15.2	473	1
27	12	16.9	246	1
28	16	11.2	221	1
29	13	13.7	345	1
30	13	13.0	443	1
			Detection Percentage	90% (>60%)

In addition an average minimum percentage of successful detection across all four Short pulse radar test waveforms is required and is calculated as follows:

$$\frac{P_d 1 + P_d 2 + P_d 3 + P_d 4}{4}$$ = (87%+97%+93%+90%)/4 = 91.75% (>80%)

Type 5 Radar Statistical Performance

Trial #	Filename*	1=Detection Blank=No Detection
1	Bin5Statistics_1	1
2	Bin5Statistics_2	1
3	Bin5Statistics_3	
4	Bin5Statistics_4	1
5	Bin5Statistics_5	1
6	Bin5Statistics_6	1
7	Bin5Statistics_7	1
8	Bin5Statistics_8	1
9	Bin5Statistics_9	1
10	Bin5Statistics_10	1
11	Bin5Statistics_11	1
12	Bin5Statistics_12	1
13	Bin5Statistics_13	1
14	Bin5Statistics_9	1
15	Bin5Statistics_15	1
16	Bin5Statistics_16	1
17	Bin5Statistics_17	1
18	Bin5Statistics_18	1
19	Bin5Statistics_19	1
20	Bin5Statistics_20	1
21	Bin5Statistics_21	1
22	Bin5Statistics_22	1
23	Bin5Statistics_23	1
24	Bin5Statistics_24	1
25	Bin5Statistics_25	1
26	Bin5Statistics_26	1
27	Bin5Statistics_27	
28	Bin5Statistics_28	1
29	Bin5Statistics_29	1
30	Bin5Statistics_30	1
Detection Percentage		93% (>80%)

*See the Bin5 Radar Characteristics at the end of this report.

Type 6 Radar Statistical Performance

Trial #	Pulses/Hop	Pulse Width (us)	PRI (us)	1=Detection Blank=No Detection
1	9	1	333	1
2	9	1	333	1
3	9	1	333	1
4	9	1	333	1
5	9	1	333	1
6	9	1	333	1
7	9	1	333	1
8	9	1	333	1
9	9	1	333	1
10	9	1	333	
11	9	1	333	1
12	9	1	333	1
13	9	1	333	1
14	9	1	333	1
15	9	1	333	1
16	9	1	333	1
17	9	1	333	1
18	9	1	333	1
19	9	1	333	1
20	9	1	333	1
21	9	1	333	1
22	9	1	333	1
23	9	1	333	1
24	9	1	333	1
25	9	1	333	1
26	9	1	333	1
27	9	1	333	1
28	9	1	333	1
29	9	1	333	1
30	9	1	333	1
			Detection Percentage	97% (>70%)

Bin5Statistics_1.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	9	55	1521	0.246287
2	3	6	80	1262,1901	0.924482
3	3	10	85	1824,1637	1.872273
4	1	8	100	NA	2.431316
5	1	8	95	NA	3.889790
6	3	15	95	1758,1730	4.753358
7	3	9	80	1413,1222	5.572570
8	3	17	50	1397,1158	5.918443
9	2	10	80	1977	6.557103
10	2	5	90	1861	7.522707
11	3	19	65	1983,1770	8.486594
12	1	12	60	NA	9.389964
13	2	11	85	1563	9.784574
14	1	16	60	NA	10.783674
15	1	5	90	NA	11.594683

Bin5Statistics_2.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	18	90	NA	0.452644
2	1	9	75	NA	2.099265
3	3	13	65	1031,1696	2.807488
4	1	5	60	NA	3.741491
5	3	16	65	1325,1857	5.409811
6	3	19	60	1880,1092	5.760215
7	1	17	80	NA	7.027694
8	1	12	100	NA	7.661985
9	1	15	55	NA	8.771149
10	3	20	55	1119,1195	10.351116
11	3	14	90	1713,1583	11.494393

Bin5Statistics_3.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	13	65	NA	0.134358
2	1	10	70	NA	1.712318
3	1	12	60	NA	2.950198
4	1	17	55	NA	4.063267
5	1	17	70	NA	4.800903
6	3	20	50	1071,1420	6.241647
7	3	11	65	1105,1203	7.291000
8	1	20	65	NA	9.476822
9	1	12	90	NA	10.744746
10	1	12	70	NA	11.877409

Bin5Statistics_4.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	17	50	1414,1793	0.392262
2	1	5	65	NA	1.300813
3	1	10	75	NA	2.058838
4	2	19	60	1624	2.330585
5	1	14	60	NA	3.349062
6	3	17	75	1448,1433	4.190149
7	1	8	55	NA	4.395628
8	1	17	95	NA	5.162492
9	2	14	50	1559	5.927574
10	3	18	65		6.684199
11	3	15	55	1005,1949 1215,1314	7.609330
12	2	9	90	1884	8.071826
13	2	12	50	1199	8.541376
14	1	20	65	NA	9.435895
15	2	17	65	1220	9.896956
16	1	13	50	NA	10.784747
17	1	5	75	NA	11.375583

Bin5Statistics_5.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	7	75	1345,1830	0.942297
2	3	11	85	1011,1989	1.958298
3	2	16	60	1584	3.230325
4	1	7	90	NA	5.367928
5	2	9	95	1087	6.574788
6	1	18	80	NA	8.239984
7	3	9	60	1749,1221	9.783378
8	3	15	50	1548,1840	11.741036

Bin5Statistics_6.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	5	100	NA	0.790197
2	1	7	85	NA	2.410497
3	3	12	75	1405,1036	3.244272
4	2	7	100	1699	5.742278
5	3	8	95	1639,1341	6.693310
6	1	16	75	NA	8.333037
7	2	18	80	1640	9.014737
8	1	11	80	NA	11.871922

Bin5Statistics_7.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	15	60	1595,1224	0.457801
2	3	11	100	1591,1089	1.061580
3	3	9	90	1977,1765	1.603406
4	2	15	65	1343	2.203330
5	2	9	70	1295	2.494725
6	2	5	60	1401	3.520407
7	3	16	60	1062,1661	3.616961
8	3	19	100	1836,1737	4.207720
9	1	16	60	NA	5.103347
10	3	11	55	1814,1493	5.988766
11	1	15	65	NA	6.186605
12	1	7	70	NA	6.803399
13	3	13	60	1535,1037	7.441443
14	3	6	100	1270,1482	7.827951
15	1	14	75	NA	8.731000
16	3	18	90	1053,1161	9.234468
17	2	10	70	1130	9.958936
18	2	5	95	1793	10.364713
19	2	14	50	1217	11.052249
20	3	20	55	1154,1427	11.882144

Bin5Statistics_8.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	16	90	1456,1571	0.353281
2	1	14	90	NA	0.836312
3	1	15	75	NA	1.382728
4	1	9	70	NA	2.185795
5	3	6	75	1297,1226	2.662728
6	1	13	95	NA	3.564776
7	2	6	100	1594	3.971332
8	3	8	50	1825,1923	4.508699
9	2	14	95	1836	5.361428
10	1	16	50	NA	5.536490
11	3	13	60	1234,1066	6.349730
12	2	20	60	1446	7.019008
13	2	12	100	1467	7.789912
14	2	14	55	1591	7.924687
15	3	6	50	1128,1434	8.825602
16	1	19	60	NA	9.028199
17	2	20	80	1513	9.790945
18	1	12	65	NA	10.756373
19	3	6	65	1892,1028	11.244397
20	2	10	80	1695	11.693240

Bin5Statistics_9.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	10	65	1319,1320	0.123725
2	1	13	95	NA	0.679258
3	2	10	55	1710	1.561018
4	2	9	95	1460	2.029640
5	3	8	85	1586,1947	2.816176
6	2	17	90	1359	3.488058
7	2	19	60	1523	3.833848
8	1	10	75	NA	4.600990
9	2	16	70	1207	5.355715
10	3	12	60	1776,1186	5.565856
11	3	12	75	1803,1524	6.203642
12	2	9	60	1267	7.149198
13	1	18	70	NA	7.380846
14	3	11	55	1636,1448	8.090914
15	1	6	65	NA	8.597364
16	3	7	70	1461,1760	9.466593
17	2	19	60	1501	9.961888
18	3	17	60	1302,1156	10.395089
19	2	15	75	1416	10.956211
20	3	15	70	1654,1259	11.461361

Bin5Statistics_10.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	20	100	1337,1945	0.917037
2	3	5	85	1636,1035	2.737162
3	2	20	85	1185	3.893494
4	2	11	80	1808	5.542858
5	1	6	55	NA	6.082829
6	2	14	60	1234	8.796411
7	1	9	70	NA	9.529375
8	2	9	100	1877	10.700461

Bin5Statistics_11.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	14	60	NA	0.990167
2	3	9	70	1406,1986	2.244706
3	3	8	90	1106,1488	2.960573
4	3	15	50	1739,1038	4.509384
5	1	19	90	NA	5.033382
6	3	6	85	1678,1959	6.756751
7	1	9	70	NA	7.485086
8	1	8	90	NA	8.784489
9	2	14	50	1147	10.581212
10	2	10	65	1020	11.289374

Bin5Statistics_12.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	19	95	1225,1231	0.033670
2	2	13	75	1867	0.761849
3	1	17	50	NA	2.105049
4	3	12	90	1445,1620	2.436484
5	1	17	60	NA	3.322861
6	2	6	65	1156	4.041820
7	3	11	75	1341,1667	4.559879
8	1	14	80	NA	5.605528
9	3	17	55	1303,1906	6.491394
10	3	13	80	1016,1672	7.064682
11	1	10	70	NA	8.238815
12	3	18	80	1536,1619	8.671898
13	3	9	80	1852,1505	9.459053
14	3	7	50	1699,1838	10.434823
15	1	6	50	NA	10.937071
16	1	7	65	NA	11.572879

Bin5Statistics_13.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	5	100	1994,1657	0.212483
2	2	7	65	1908	1.737974
3	1	11	80	NA	1.850478
4	1	19	50	NA	3.154995
5	2	6	75	1708	4.606621
6	3	8	60	1760,1885	5.508717
7	2	10	100	1403	5.784591
8	2	12	55	1734	7.043373
9	2	20	80	1130	8.202944
10	1	12	95	NA	8.338472
11	3	11	65	1894,1082	9.662044
12	3	19	65	1257,1910	10.352585
13	3	18	65	1564,1246	11.820741

Bin5Statistics_14.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	14	85	NA	0.398389
2	3	15	95	1630,1500	1.151616
3	2	10	95	1005	2.037676
4	1	5	90	NA	3.273951
5	2	15	75	1491	3.766544
6	1	12	80	NA	4.569432
7	3	8	50	1942,1764	5.498577
8	1	12	50	NA	6.731193
9	2	12	55	1555	7.270068
10	3	17	100	1643,1419	8.408891
11	1	7	85	NA	9.260391
12	3	7	75	1258,1416	9.544812
13	1	18	95	NA	10.915297
14	3	7	90	1623,1394	11.162282

Bin5Statistics_15.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	18	100	1847	0.549291
2	3	11	80	1095,1664	1.710120
3	1	5	100	NA	2.092751
4	3	8	70	1790,1146	3.084616
5	2	16	50	1299	4.423566
6	1	15	70	NA	4.956382
7	1	12	85	NA	5.711146
8	2	14	50	1063	6.999373
9	1	20	70	NA	7.949971
10	1	7	55	NA	8.698228
11	3	20	90	1628,1382	9.364847
12	3	12	85	1857,1720	10.478761
13	3	17	80	1133,1861	11.374023

Bin5Statistics_16.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	20	95	1972	0.982727
2	1	18	100	NA	1.266440
3	2	14	90	1898	3.517665
4	1	20	55	NA	4.497820
5	3	11	80	1861,1717	5.106569
6	2	12	60	1660	7.073856
7	3	7	55	1645,1085	8.323434
8	2	15	55	1694	9.512301
9	2	18	55	1434	10.480360
10	2	12	80	1088	11.621332

Bin5Statistics_17.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	9	75	1153	1.088453
2	3	9	60	1680,1359	2.051927
3	1	20	90	NA	3.327541
4	1	13	90	NA	4.183652
5	3	9	100	1795,1157	4.880381
6	1	15	75	NA	7.126289
7	2	10	85	1748	7.231523
8	2	19	75	1952	8.469657
9	3	12	100	1492,1044	10.544474
10	3	11	80	1069,1485	11.068740

Bin5Statistics_18.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	16	90	1354	0.627796
2	1	13	50	NA	2.059322
3	1	14	55	NA	2.936790
4	2	8	50	1956	3.778622
5	2	12	50	1240	4.658820
6	2	15	95	1193	5.525153
7	1	20	70	NA	6.558312
8	1	13	100	NA	8.618717
9	2	12	65	1267	9.057408
10	1	14	75	NA	10.852975
11	2	14	90	1086	11.214612

Bin5Statistics_19.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	11	50	NA	0.295058
2	3	13	60	1022,1096	0.758336
3	3	7	65	1560,1592	1.890348
4	1	13	85	NA	1.896963
5	3	8	95	1398,1163	2.846130
6	1	14	65	NA	3.378350
7	1	15	90	NA	3.973148
8	3	15	100	1633,1157	4.970687
9	1	11	95	NA	5.125884
10	3	16	70	1508,1771	5.712335
11	1	12	70	NA	6.943145
12	2	14	65	1297	7.392205
13	1	12	75	NA	7.639831
14	1	15	55	NA	8.491171
15	3	6	90	1495,1376	9.295285
16	2	10	100	1741	9.504974
17	1	9	75	NA	10.468330
18	2	5	50	1507	11.065044
19	3	9	80	1833,1428	11.864814

Bin5Statistics_20.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	16	50	2000	0.372643
2	3	6	50	1398,1499	1.232612
3	1	19	85	NA	1.514363
4	3	16	65	1298,1593	2.532303
5	3	19	65	1035,1000	3.017801
6	3	11	80	1954,1369	3.878699
7	1	20	80	NA	5.075896
8	2	5	80	1283	5.919874
9	1	6	85	NA	6.424047
10	1	6	65	NA	7.294505
11	3	5	80	1858,1520	8.236850
12	2	9	80	1698	8.526208
13	2	10	50	1800	9.562765
14	3	11	80	1997,1651	9.780188
15	1	20	65	NA	10.823517
16	1	19	55	NA	11.918558

Bin5Statistics_21.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	15	95	1090	0.154670
2	2	12	60	1730	1.754179
3	3	10	95	1166,1941	2.618319
4	3	19	75	1018,1841	3.538059
5	3	15	85	1744,1809	4.435161
6	2	16	90	1586	5.604252
7	1	9	100	NA	6.358547
8	2	7	70	1314	7.562533
9	3	18	65	1257,1357	8.731204
10	3	12	50	1838,1221	9.004081
11	1	17	100	NA	10.311876
12	1	14	80	NA	11.492352

Bin5Statistics_22.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	15	50	1833	0.733368
2	3	10	100	1150,1568	1.357979
3	3	10	80	1095,1252	2.800413
4	2	11	100	1497	4.247862
5	3	20	70	1680,1707	5.373839
6	3	10	70	1391,1656	5.793849
7	3	15	85	1604,1732	6.726478
8	2	10	85	1101	8.529162
9	2	6	75	1019	9.002649
10	2	10	85	1399	10.746289
11	2	12	60	1828	11.618874

Bin5Statistics_23.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	16	80	1819,1773	0.192466
2	2	13	50	1535	1.405143
3	3	11	55	1221,1185	2.761553
4	2	8	85	1826	4.020767
5	3	20	60	1872,1156	5.491484
6	3	8	50	1633,1412	7.137450
7	3	17	90	1066,1569	8.263974
8	1	8	100	NA	10.072129
9	1	19	60	NA	10.765613

Bin5Statistics_24.txt

Burst#	Pulses		PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	3	Chirp(MHz) 9	85	1613,1283	0.346674
2	3	11	100	1622,1911	1.009025
3	2	12	75	1469	2.027916
4	3	11	70	1410,1545	3.007877
5	3	17	90	1960,1422	3.903858
6	2	19	65	1064	4.374226
7	1	16	70	NA	5.303858
8	2	10	65	1650	5.729172
9	2	10	50	1238	6.960769
10	3	15	80	1055,1798	7.350575
11	2	7	60	1901	8.479697
12	1	9	60	NA	9.023576
13	3	8	55	1646,1897	10.114573
14	1	17	80	NA	11.155209
15	1	17	85	NA	11.327446

Bin5Statistics_25.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	8	90	1881	0.114491
2	3	16	100	1391,1864	1.879320
3	1	20	65	NA	2.885220
4	2	19	80	1770	3.593760
5	1	20	95	NA	4.424549
6	2	19	90	1307	5.594003
7	1	11	65	NA	6.153904
8	2	6	95	1302	7.160734
9	2	13	50	1485	8.404539
10	3	13	70	1797,1591	9.319933
11	3	13	60	1768,1822	10.480072
12	2	6	85	1218	11.280752

Bin5Statistics_26.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	8	80	NA	0.304141
2	1	15	80	NA	1.507392
3	2	16	85	1112	3.216967
4	3	20	95	1968,1181	5.328848
5	3	13	60	1429,1737	6.022028
6	3	8	90	1385,1562	7.551800
7	1	8	70	NA	9.405552
8	1	10	60	NA	10.827510

Bin5Statistics_27.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	12	75	1663	0.487285
2	2	19	90	1709	2.135252
3	1	6	85	NA	3.140017
4	1	5	55	NA	4.745021
5	1	17	95	NA	6.916680
6	3	5	85	1265,1022	7.778005
7	1	6	55	NA	9.109545
8	3	6	75	1828,1069	11.041950

Bin5Statistics_28.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	20	50	1059	0.911509
2	2	7	95	1195	1.350836
3	1	20	100	NA	2.522307
4	1	16	95	NA	4.131000
5	2	19	95	1262	5.239877
6	2	15	70	1067	5.899036
7	3	20	55	1507,1757	6.678873
8	2	10	100	1352	8.059416
9	1	19	70	NA	9.811315
10	2	17	50	1679	10.878139
11	3	12	90	1242,1078	11.549879

Bin5Statistics_29.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	1	15	55	NA	0.404580
2	1	16	55	NA	1.449394
3	3	20	75	1789,1807	2.016031
4	1	14	80	NA	2.689175
5	3	19	50	1661,1776	3.206599
6	2	14	55	1729	4.169881
7	3	9	50	1293,1404	5.284722
8	2	19	60	1509	6.331572
9	3	14	60	1354,1849	6.652558
10	3	13	70	1692,1200	7.263614
11	3	14	90	1071,1318	8.162366
12	3	13	90	1674,1911	8.972822
13	1	17	90	NA	10.125491
14	2	20	90	1832	10.821064
15	2	19	50	1753	11.824729

Bin5Statistics_30.txt

Burst#	Pulses	Chirp(MHz)	PW(uS)	Inter-pulse spacing/s(uS)	Pulse Start(S)
1	2	10	70	1462	0.127083
2	1	19	85	NA	0.873202
3	1	16	55	NA	1.779357
4	3	13	55	1589,1655	2.026120
5	1	6	70	NA	2.682897
6	2	13	75	1694	3.166846
7	3	7	65	1747,1684	4.166501
8	2	6	90	1731	4.819822
9	3	18	60	1798,1544	5.434693
10	2	5	70	1242	6.174259
11	1	11	90	NA	6.819444
12	3	12	50	1506,1289	7.399999
13	2	5	90	1364	7.886215
14	1	6	95	NA	8.322875
15	3	19	70	1146,1661	9.416912
16	2	15	85	1949	9.509949
17	3	14	50	1280,1797	10.731485
18	3	7	90	1925,1662	10.760541
19	2	5	65	1162	11.509563